THE OPHTHALMOSCOPE

J. HERBERT CLAIBORNE JR.

THE

THEORY AND PRACTICE

OF THE

OPHTHALMOSCOPE.

A HAND-BOOK FOR STUDENTS.

BY

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1888.
GEORGE S. DAVIS,
DETROIT, MICH.

TO MY FATHER,

DR. JOHN HERBERT CLAIBORNE,

OF VIRGINIA,

THIS MANUAL IS AFFECTIONATELY

DEDICATED.

PREFACE.

In presenting this brochure to the medical profession, the author has not hoped to establish a claim for originality. The lines are cast in familiar places. His object has been to present in a clear and brief manner the main facts in ophthalmoscopy and the method of using the ophthalmoscope.

While a reasonable degree of success in teaching the use of the instrument has led him to formulate his ideas in writing, it is not without a certain amount of fear that he subjects his first essay to public criticism.

TABLE OF CONTENTS.

CHAPTER I.

CHAPTER II.

CHAPTER III.

CHAPTER IV.

CHAPTER V.

CHAPTER VI.

CHAPTER VII.

CHAPTER VIII.

CHAPTER IX.

INTRODUCTION.

The object of this introduction is to say a few words to those who propose to read this manual carefully. The selection of the matter preliminary to the "Methods of using the Ophthalmoscope," has not been unattended with difficulty. The difficulties have been to avoid in the first place exuberance, in the second too great conciseness. The author has found in teaching that a correct understanding of those facts in optics which are set forth in the first three chapters, is absolutely necessary to the scientific use of the ophthalmoscope. It might be supposed that most students are acquainted with these elementary principles; it has been the author's fortune to teach many who evidently knew nothing of them. It will be observed that repetition characterizes this manual. It has been intentional. There is no more certain method of producing an impression. It is hoped that clearness has not been sacrificed to brevity. The methods of using the instrument have been divided somewhat differently from others. It will be observed that *four* headings are employed. Retinoscopy and the Vessel Test has been put under the first method, the reflected. Most teachers suggest the oblique illumination as the first method. By this method the physical condition alone of the cornea, aqueous humour, lens, and anterior portions of the vitreous

humour are recognized. By the Reflected method, not only is this information obtained, but the Vessel Test and Shadow Test may be employed at the same time, and a definite idea be gotten of the quality and the approximate quantity of the refraction. Surely that method of procedure is most to be commended which enables one to obtain the greatest amount of information in the shortest time and with the least effort. To those who would follow the teachings of this manual, it is earnestly suggested that the following sequence in examination be observed:

1st. The Reflected Illumination, (*a*) Vessel Test, (*b*) Shadow Test or Retinoscopy. 2nd. Oblique Illumination. 3rd. The Indirect Method. 4th. The Direct Method. It is the author's desire to call especial attention to the chapter on Retinoscopy. This method is too little used in this country. As a qualitative and as an approximately quantitative method of estimating the refraction of an eye it is in the highest degree to be commended. The quantitative determination of errors of refraction by this method with the aid of the trial case, the author has employed only in the class of cases referred to in the Chapter on this subject. The disinclination on the part of some ophthalmologists in this country to use this method at all can only be attributed to over-conservatism. Although it is not properly in the scope of this manual as proclaimed by the title, it has been deemed wise to add a chapter on Mydriatics. The

following authorities have been consulted in the preparation of this monograph: Landolt, Schweigger, Soelberg Wells, Juler, Swanzy, Nettleship, Hartridge, Morton and others.

In conclusion the author wishes to express his thanks to Dr. John Dunn, for the valuable criticisms and suggestions made during the preparation of the following pages.

J. H. C. Jr.

CHAPTER I.

On a correct knowledge of the laws of optics depends the comprehension of the facts of ophthalmoscopy. For practical purposes, it is only necessary to speak of the behavior of rays of light that pass through prisms, spherically concave and convex glasses, and through cylindrical glasses, as well as that of rays incident to and reflected from concave, convex and plane surfaces.

Rays of light in passing from a less dense into a denser medium are refracted toward a perpendicular drawn to the surface of the medium at the point of entrance; in passing from a denser to a less dense are refracted from a perpendicular drawn to the surface of the medium at the point of emergence. If the rays be at right angles to the surface separating the two media, they are not refracted at all. (Fig. 1.)

At B, the ray of A B is refracted toward the perpendicular P P.

At C, the ray of B D is refracted from the perpendicular P P.

The ray H K falling at a right angle to the surface of the medium, is not refracted.

In Fig. 1, the sides of the refracting medium are parallel, but in the case of a prism the surfaces are not

parallel and a ray can therefore be perpendicular to only one surface at a time. Any ray that falls on a

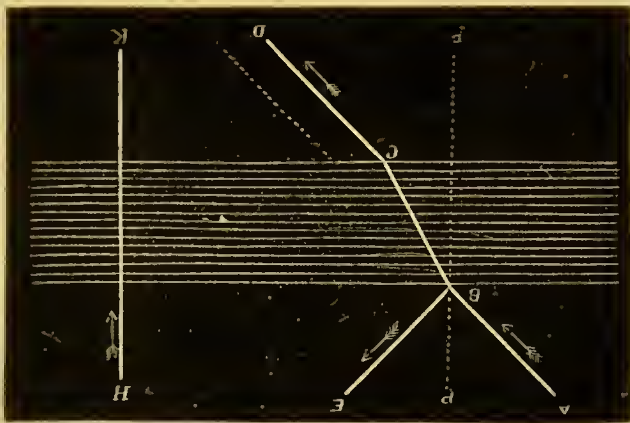

FIG. 1.

prism must be refracted and the deviation must be toward the base.

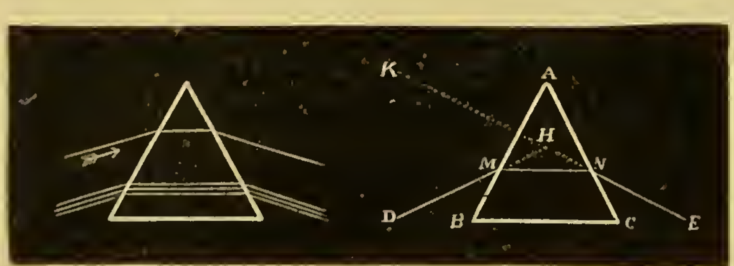

FIG. 2.

The ray D M falling upon a prism is bent in the direction M. N.; at N it is again bent so that an ob-

server catching the ray at E, would receive it as if it came from K. Let it be observed that the relative direction of the rays is unaltered.

Convex and concave lenses may be regarded as being composed of prisms; the former with their bases, the latter with their apices opposed.

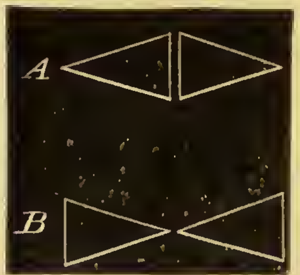

Fig. 3.

Since rays in passing through a prism are refracted towards its base, we can readily comprehend the fact that convex lenses cause convergence, and concave lenses divergence of rays.

A line which passes through the centre of a lens (optical centre) at right angles to the surfaces of the lens, is called the *principal axis*. A ray passing through this axis is not refracted.

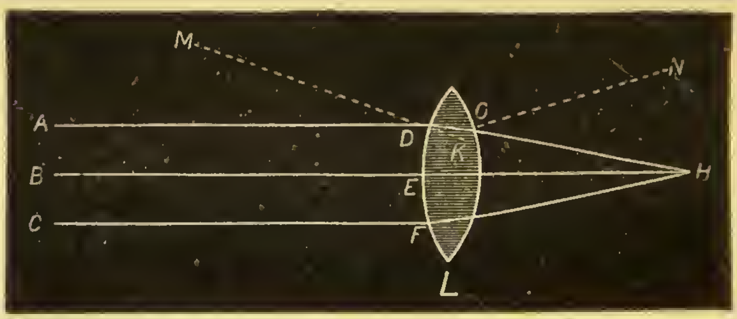

Fig. 4.

The ray B strikes the lens L at a right angle to its surface and pursues a straight course to the point H. The ray A strikes the lens L obliquely at D and is refracted toward a perpendicular to the surface of the lens at that point, as shown by the dotted lines MK. On leaving the lens at O the ray is refracted away from the perpendicular NO and meets the central ray B at the point H. The ray C in like manner meets the other rays at H.

Parallel rays then passing through a biconvex lens are rendered convergent.

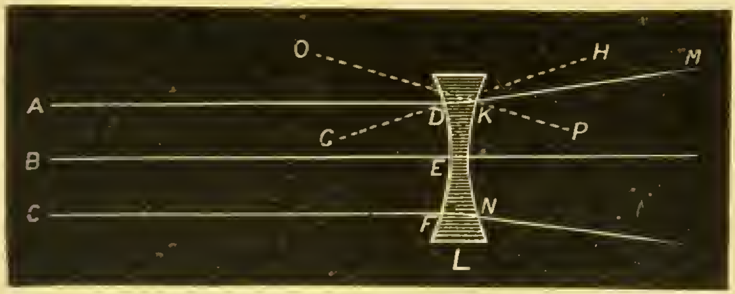

FIG 5.

The ray B strikes the lens L at a right angle and is not refracted. The ray A strikes the lens L obliquely at D and is refracted towards the perpendicular, G H. On emerging from the lens at K it is bent away from the perpendicular O P in the direction K M. The like takes place with the ray C.

Parallel rays then passing through a bi-concave lens are rendered divergent.

All rays that do not pass through the principal axis are refracted. Those rays that pass through the optical centre but not through the principal axis are termed *secondary rays.*

Fig. 6.

They do undergo refraction, but in thin lenses it is so slight that they are assumed to pass in a straight line.

Parallel rays passing through a convex lense (L) are brought to a focus (A) at a certain fixed distance from the optical centre of the lens. Such a point is

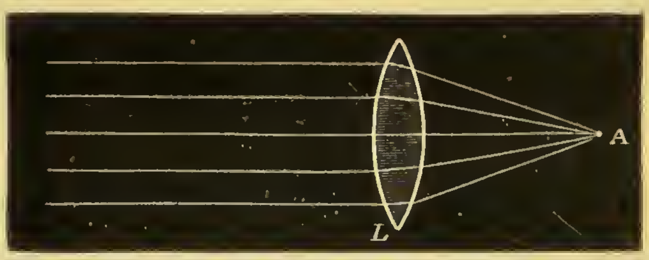

Fig. 7.

called the *principal focus* of the lens, and the distance of this point from the optical centre of the lens is called the *focal distance* of the lens.

If parallel rays, passing through a concave lens be rendered divergent, the focus must be a virtual,

negative one, situated on the same side of the lens as the object from which the rays proceed. If the divergent rays in Fig. 8 below, be continued backward, they will meet at F. the *principal focus.*

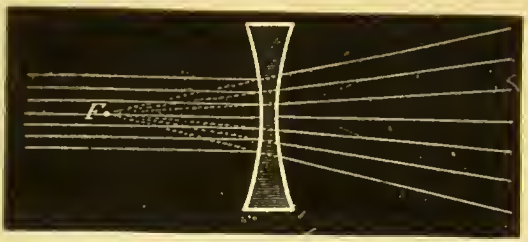

FIG. 8.

Spherical lenses may be plano-convex (Fig. 9, 1), that is, having one surface plane and the other convex; double convex (Fig. 9, 2), having both surfaces convex with the same radius of curvature to both; converging concavo-convex (Fig. 9, 3), having one surface concave and the other convex, with the predominance of the latter, the so-called *positive meniscus;* plano-concave (Fig. 9, 4), double or bi-concave (Fig. 8, 5); diverging concavo-convex (Fig. 8, 6), with predominance of the concavity, the *negative meniscus.*

Cylindrical glasses are segments of cylinders. If we describe a circle on the outer side of an upright solid glass cylinder, the portion included within the circle will represent the surface of a convex cylindrical glass. The transverse diameter will have the greatest

radius of curvature, the vertical meridian which corresponds to the axis of the cylinder will be plane.

Fig. 9.

If we describe a circle on the inner side of an upright hollow glass cylinder, the portion included within the circle will represent the surface of a concave cylindrical glass. The transverse diameter will have the greatest radius of curvature, the vertical which corresponds to the axis of the cylinder, will be plane.

Such glasses therefore refract only those rays which are at right angles to their axis.

Cylindrical glasses are usually made plano-convex and plano-concave, and parallel rays passing through them at right angles to their axis are rendered convergent or divergent respectively.

The axis of cylindrical glasses are often indicated by ground lines, one on either side of the lens or by the glass being ground rough on either side, so that the edges of the ground portion are parallel with the axis.

CHAPTER II.

The convex lens which brings parallel rays of light to a focus one inch from its optical centre is taken as the standard for convex spherical and cylindrical glasses. Such a lens is called a convex number one. Having a standard, we may proceed to others; a convex lens which unites parallel rays at two inches from its optical centre is termed a convex number two, and so on. *The strength of lenses is inversely as their focal distances.* The strength of a convex number two is obviously one-half as great as that of a convex number one.

The strength of lenses is expressed in the form of a vulgar fraction, $\frac{1}{2}$, $\frac{1}{6}$, $\frac{1}{10}$, and so on.

The concave lens, which gives to parallel rays such a divergence that, if prolonged backward, they will meet one inch from the optical centre of the lens, is taken as the standard for concave spherical and cylindrical glasses.

Such a lens is called a concave number one. A concave number two would give parallel rays such a divergence that if prolonged backward, they would meet two inches from the optical centre of the lens. The strength of the latter is obviously one-half that of the former.

Convex glasses that are written with the algebraic plus sign before them: $+\frac{1}{2}$, $+\frac{1}{30}$, $+\frac{1}{60}$, etc.; concave glasses with the algebraic minus sign before them: $-\frac{1}{6}$, $-\frac{1}{12}$, $-\frac{1}{80}$, etc.

In this country glasses are usually recorded in the form of vulgar fractions; in England and on the continent the French system of dioptrics or dioptries* is commonly used. One dioptry is the equivalent of $\frac{1}{36}$ or $\frac{1}{40}$, accordingly as the French or English inch is taken as the standard.

When written in dioptries, the numbering of glasses is done in integers and decimal fractions: $+\frac{1}{40} = 1 + D$, $-\frac{1}{24} = -1.5$ D, $+\frac{1}{80} = +0.5$ D, $-\frac{1}{8} = -5$ D, etc.

The tabulated statement of the following facts is deemed pertinent:

1. Parallel rays passing through a convex lens are brought to a focus at a certain distance from the optical centre of the lens. The point at which they unite is termed the Principal Focus of the lens. The image is inverted and smaller than the object from which the rays proceeded. (Fig. 10.)

The candle A B is *presumably* placed at infinite distance; the rays from it proceed to the lens parallel.

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* The choice between the words *dioptry* and *dioptric* may be left to the taste of the reader. Quite an animated discussion has taken place in the New York medical journals in regard to this point between Dr. Swann M. Burnett, of Washington, D. C., and the late Dr. Loring, of New York. Perhaps Dr. Knapp has suggested the most plausible means of settling the difficulty—by referring the matter to the *Queen*, whose language we speak.

b a is the real inverted diminished image of the object A B, and is situated at the Principal Focus of the lens.

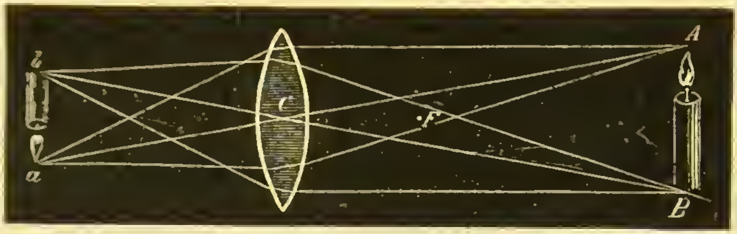

FIG. 10.

2. If the rays proceed from an object situated at twice the focal distance of the lens, the image will be formed at twice the focal length behind the lens, and will be of the *same* size as the object.

3. If the object be situated at the focal distance (principal focus) of the lens, they will emerge from the lens parallel, no image will therefore be formed.

4. If the rays proceed from an object situated within the focal distance of the lens, they will emerge from the lens divergently. The *image* will be virtual and will appear to an observer's eye, placed in the track of the emerging rays, *upright* and *larger* than the object. (Fig. 11.)

The candle A B is situated within the focus F. The rays from the candle A B pass through the lens and emerge divergently. Some of these divergent rays are caught by the eye E, and are received as if

they came from a b. The image a b is larger than the object A B, and is upright.

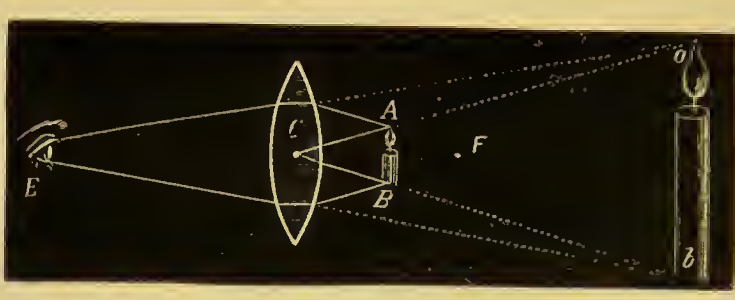

FIG 11.

In concave glasses the image is on the same side of the lens as the object (virtual) is upright and smaller than the object.

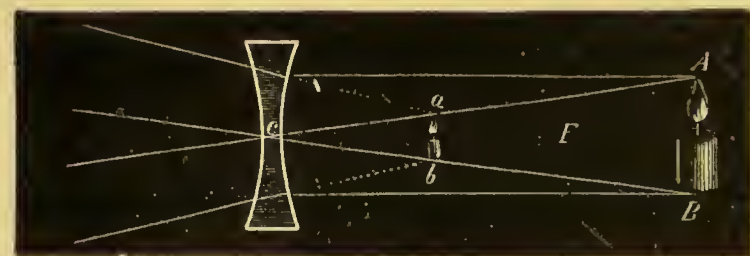

FIG. 12.

Rays coming from the candle A. B. pass through the concave lens C and emerge divergently. These divergent rays, to an observer who looks at A. B. through the lens, have the appearance of coming from a. b.

While a *real* image may be thrown upon a screen, a *virtual* one can only be seen by looking through the lens.

The distance of the image from the lens in convex glasses may be found by the following formula:

$$\frac{1}{x} = \frac{1}{b} - \frac{1}{a}$$

where

x = the distance of the image from the lens.
b = the focal length of the lens.
a = the distance of the object from the lens.

1. Suppose rays from an object at infinite distance (parallel rays) pass through a 2 inch convex lens: to find x, the distance of the image from the lens.

$$\frac{1}{x} = \frac{1}{2} - \frac{1}{\infty} = \frac{1}{2} - \frac{1}{0} = \frac{1}{2} \therefore x = 2 \text{ inches.}$$

2. Suppose rays coming from an object at four inches, pass through a two inch convex lens; to find x.

$$\frac{1}{x} = \frac{1}{2} - \frac{1}{4} = \frac{1}{4} \therefore x = 4 \text{ inches.}$$

3. Suppose rays coming from an object at two inches, pass through a two inch convex lens; to find x.

$$\frac{1}{x} = \frac{1}{2} - \frac{1}{2} = 0 \therefore x = \frac{1}{0} = \infty = \text{infinity.}$$

5. The distance of the image from the lens in concave glasses may be found by the formula:

$$\frac{1}{x} = \frac{1}{b} - \left(-\frac{1}{a}\right) = \frac{1}{b} + \frac{1}{a}$$

with the same valuations as in the formula for convex glasses.

Reflection. Rays of light incident to a polished surface are chiefly reflected.

The angles of incidence and reflection are always equal.

FIG. 13.

A B is the ray incident to the surface C D. B E is the reflected ray. The perpendicular P B divides the angle A B E into two equal parts. The angle A B P is then equal to the angle P B E.

In reflection from a plane mirror, the image is projected behind the mirror, is upright, of the same size as the object, and at the same distance from the mirror as the object. (Fig. 14.)

The image of the candle *C* is projected behind the mirror *M* at *C'*, a distance behind the mirror equal to the distance of the candle in front of it. The eye E receives the rays from the candle C as if they came from C'.

Parallel rays falling upon a concave mirror are reflected as convergent rays; these convergent rays form a focus on the axis of the mirror at a point *F* (Fig. 15), which is called the *principal focus*. If the

source of illumination be placed at F, the rays will be reflected parallel. If the source of illumination be placed at *a*, the rays will be focussed at A; if it be

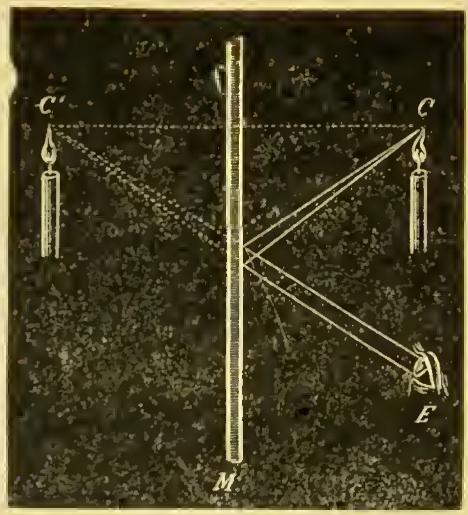

FIG. 14.

placed at A, they will unite at *a*; these two points are the *conjugate foci* of the mirror. C is the "centre of concavity" of the mirror; if the source of the illumination be placed at C, the rays will be focussed at C; the object and image will then be at the same point.

If a person look at his face in a concave mirror at a certain distance beyond the principal focus, his features will appear reversed and diminished; at the principal focus they will disappear; *within* the principal focus, they will appear upright and enlarged.

Parallel rays falling upon a convex mirror are reflected as divergent rays; hence they never come to a focus. If the rays thus rendered divergent be pro-

FIG. 15.

longed backward, they will meet at a point F (Fig. 16) on the other side of the mirror, the *principal focus.* The image is here virtual.

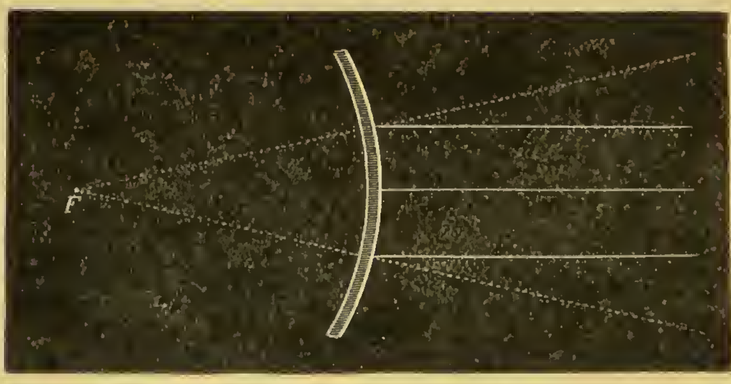

FIG. 16

If a person look at his face in a convex mirror, his features will appear diminished and upright; the nearer he approches, the larger they become, while they still remain upright.

CHAPTER III.

Optic Axis.—The optic axis is coincident with a line drawn through the centre or apex of the cornea backward, impinging on the retina at a point situated slightly to the inner side of the macula lutea.

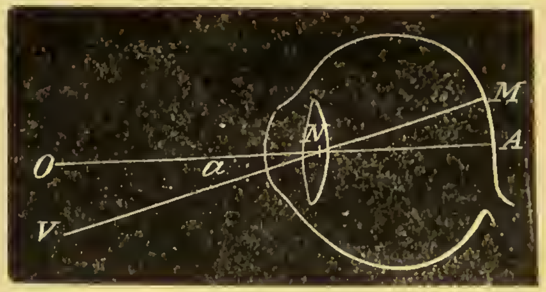

FIG. 17.

The optic axis is represented in Fig. 17 by the line O A.

Visual Axis.—The visual axis is coincident with a line drawn from the point of fixation (object looked at) to the fovea centralis in the macula lutea. The line V M in Fig. 17 represents the visual axis.

Nodal Point.—The nodal point is the point of intersection of the optic and visual axis.

It is situated in the crystalline lens, just in front of its posterior surface.

In Fig. 17, N is the nodal point, where the lines O A and V M intersect.

Emmetropia (’εν, within, μέτρον, measure, ’ώψ,

eye), is that condition of the refraction of the eye in which, when the muscle of accommodation is in a state of rest, parallel rays of light are brought to a focus at the macula lutea. The symbol is E.

Ametropia ('α, privative, με΄τρον, ʼ΄ωψ) is a general term, signifying that an eye is *not* emmetropic. Symbol A.

Hypermetropia (ʽυ΄πέρ, over, beyond, μέτρον, ʺωψ) is that state of refraction in which, when the accommodative muscle is in a condition of rest, parallel rays of light are brought to a focus behind the retina (macula lutea). Symbol H.

* Myopia (μ`υειν, to close, ʺωψ) is that state of refraction in which, parallel rays of light are focussed in front of the retina (macula lutea). Symbol M. (Fig. 18.)

A, Emmetropic eye, *B*, Hypermetropic eye, *C*, Myopic eye.

The name Myopia is taken from the fact that near-sighted people often close their eyes slightly in order to lessen the size of the "circles of diffusion" on the retina, thereby gaining a more distinct image of the objects.

Astigmatism ('α, privative, στίγμα, a point) is the condition in which the refraction of the different meridians varies in the same eye.

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* In E, the visual axis, at the cornea lies to the inner side and slightly above the optic axis, forming with it an angle (the "angle α," Fig. 17) of about 5°. In H the angle α is greater than in E. In M it is smaller, or, at times the visual and optic axes are coincident, or, the "angle α" may even be negative.

One meridian may be emmetropic, the other myopic or hypermetropic—simple myopic astigmatism, symbol As. M. or simple hypermetropic astigmatism, As. H.

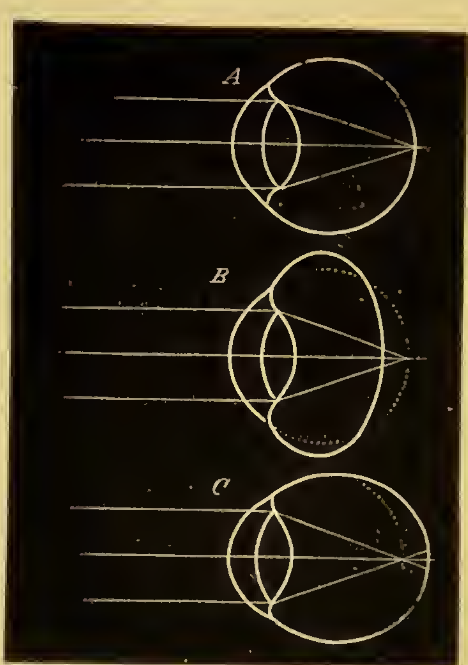

Fig. 18.

Both meridians may be myopic, one more so than the other, compound myopic astigmatism As. M. + M.; both may be hypermetropic, one more so than the other, compound hypermetropic astigmatism, As. H. + H.

One meridian may be myopic and the other hypermetropic, mixed astigmatism.

The symbol As. H. M. is used for this condition when the H. is predominant, the symbol As. M. H, when the M. is predominant. Lastly there may be irregular astigmatism which is usually due to irregularities of the cornea from injuries, inflammations, etc., or, it may have its seat, according to some, in the lens.

Perception of a line.—A line may be considered as composed of an indefinite number of points, arranged longitudinally from which rays proceed in all directions. In order to see a line distinctly, it is necessary that the rays which emerge from the points in planes at right angles to the long axis of the line, be focussed in corresponding planes on the retina.

A vertical line is seen through the horizontal meridian of the eye. The horizontal rays proceeding from each point that helps to make the vertical line, pass through the horizontal medium of the eye and are focussed as a point on the retina. Such points being arranged in a vertical series, the vertical line is reproduced. A horizontal line is seen through the vertical meridian of the eye. The vertical rays that proceed from the points which go to make up the horizontal line, pass through the vertical meridian and are focussed as points in a horizontal series on the retina. The horizontal line is thus reproduced. If, in any meridian rays are not focussed on the retina, as in As. H. or As. M., "circles of diffusion" will be formed instead of points. The line from which such rays proceed will then be seen indistinctly.

The Near Point (Punctum Proximum) is the nearest point of distinct vision, *i. e.* the nearest point for which the eye can accommodate itself. Symbol, P.P.

It is nearest in childhood and recedes as age advances, on account of the loss of resiliency in the lens and the diminution of the power of the accommodative muscle (Presbyopia).

The Far Point (*Punctum Remotissimum*) is the "furthest point of distinct vision." It is constant for a given condition of refraction. Symbol P. R. In order to comprehend fully the significance of the Far Point, the following considerations are necessary. Bearing in mind the definitions of E. H. and M., and the tabulated statements given on page 12, we can readily understand how rays of light emerge from eyes. Parallel rays are brought to a focus upon the retina (macula lutea of emmetropic eyes); if the luminous point be situated on the retina of such an eye rays from it would emerge *parallel*. Conferre 3, page 13.

FIG. 19.

The bundles of rays A C and B D emerge from

the eye parallel; the image of the retina is therefore not formed at all.

The furthest point of distinct vision for an emmetropic eye lies, theoretically at infinity. Parallel rays are brought to a focus behind the retina of a hypermetropic eye. If the luminous point be situated on the retina, rays from it will emerge from the eye divergently. Conferre 4, page 13.

FIG. 20.

The rays from the points A and B emerge from the eye in two sets of diverging rays which have the appearance of coming from the points a and b, situated behind the retina. The greater the divergence of the emerging rays the nearer to the retina (more properly the nodal point), will they meet, when prolonged backward. The points a and b represent the Far Point of a hypermetropic eye. The greater the hypermetropia, then, the nearer will the far point be to the nodal point. The image formed is erect.

Parallel rays of light are brought to a focus in front

of the retina of a myopic eye; rays from a luminous point situated on a retina of such an eye will emerge from the eye convergently. Conferre 2, page 13.

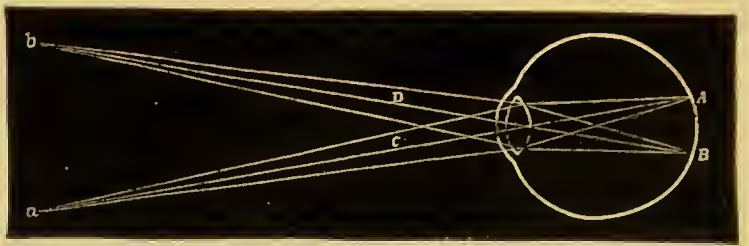

FIG. 21.

The rays from the points A and B emerge as two sets of converging rays; those from the point A uniting at a, those from the point B uniting at b. The image of the retina is therefore formed at a finite distance in front of the eye and is inverted. The points a and b represent the far point of a myopic eye. The greater the myopia then the nearer is the far point to the eye (the nodal point).

To sum up:

Rays emerge from emmetropic eyes parallel, from hypermetropic eyes divergently, from myopic eyes convergently.

Practically, we have to do with the far point only in myopia.

Myopic people cannot see distinctly beyond their far point; emmetropes can see distinctly objects at twenty feet (practically infinity, since rays coming

from objects at twenty feet are practically parallel); hyperopes also, with the power of accomodation undiminished, can see distinctly at twenty feet and theoretically should see better at greater distances than emmetropes. The terms *far point* and *near point* are used in reference to binocular and single vision.

Anisometropia in the general acceptation of the term is the condition in which the fraction of the two eyes is different in any manner.

From the etymology of the word, we are inclined to agree with Dr. Noyes, of New York, who thinks that this term should be used only when the two eyes have the same quality of refraction and differ only in degree, *i. e.*, both having H. or M., with more H. or M. in one than in the other.

Instead of the term anisometropia, to signify that the refraction of the two eyes is *simply different*, we would suggest the word, *Heterometropia.**

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* 'ετεροϛ, in composition signifies "other," "different;" this word seems to us to exactly express the meaning intended. Instead of anisometropia, Dr. Noyes has suggested the word *Antimetropia*, the Greek prefix ʾαντι (against), signifies in composition, "*opposition*," *not oppositeness.*

CHAPTER IV.

The ophthalmoscope consists of a plane or a concave mirror (when concave, usually of nine inches focal distance), embedded in a metal plate. By means of this mirror, the rays of light are reflected from the source of illumination into the eye. The mirror is pierced centrally by an aperture through which the observer looks. Behind the mirror are arranged glasses, convex and concave, which can be thrown over the aperture by a ratchet. The whole is mounted upon a handle. Two biconvex lenses are usually placed in the case; they may have a focal distance of 2, 2½ or 3 inches.

The rotating glasses should preferably be covered, in order to protect them from injury or dust. The mirror may be either tilting or stationary—here personal preference would seem to be the guide. The tilting mirror is made in the shape of a parallelogram; the area of illumination in the fundus, of course, corresponds to the shape of the mirror. The stationary mirror is usually round, at times is in the shape of a parallelogram, or a circle with a section lopped off laterally. The convex glasses are arranged on one side of the aperture, the concave on the other. The numbering of the former is usually in white, that of the latter in red. Under each glass the value in inches and dioptries is placed. In some instruments $\frac{1}{40}$ is

taken as the value of 1 D., in others $\frac{1}{36}$. An ophthalmoscope that contains 10 or 12 spherical glasses on either side of the aperture furnishes sufficient means for correct diagnosis.

The accompanying cut shows the "Polyclinic

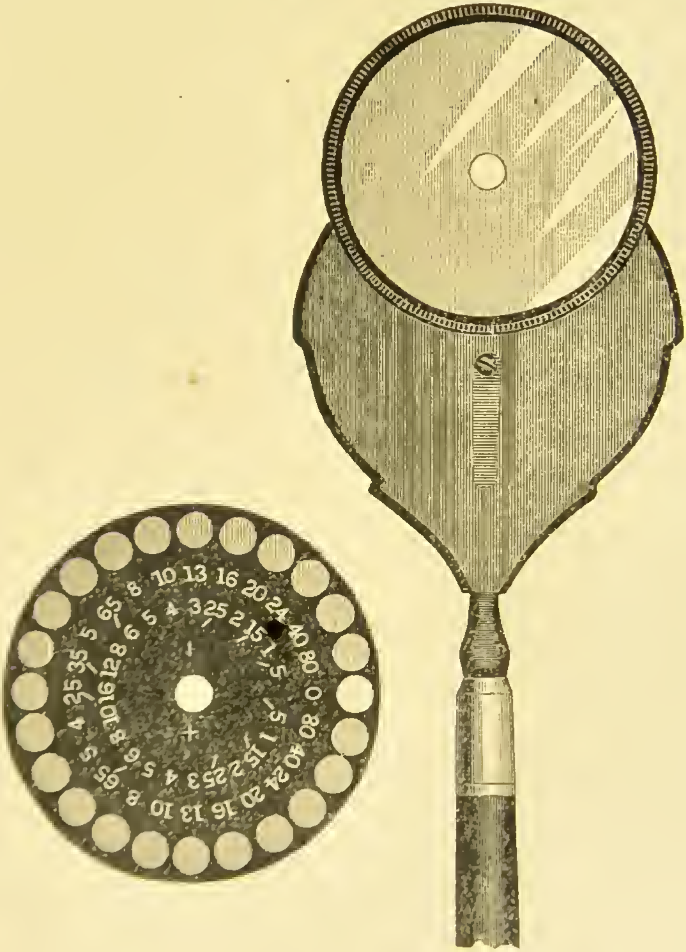

FIG. 22.

Opthalmoscope,"* which we are accustomed to use. We would suggest to the beginner the propriety of obtaining as simple an instrument as possible, within the limitations set above. We have, not infrequently seen a student thoroughly discouraged by the inability to manage a complicated instrument.

The older instruments, Liebreich's for instance, are not advisable.

* This instrument may be obtained of Mr. Ernest Goldbacher, 98 Fulton street, N. Y.

CHAPTER V.

We divide the methods of examination with the ophthalmoscope as follows:

1. Transmitted or Reflected Method, Physical Condition of the Refractive Media.

(a) Vessel Test. (b) Shadow Test or Retinoscopy.	Condition of the refraction of the eye.	(a) Qualitative and approximately quantitative. (b) Quantitative and qualitative.

2. Oblique Illumination, Inspection of the conjunctiva cornea, aqueous humour, iris, the lens and the anterior portions of the vitreous humour.

3. Indirect Method.—Qualitative and approximately quantitative determination of the refraction. 4. Direct Method.—Qualitative and quantitative determination of the refraction.	Condition of the fundus oculi.

THE TRANSMITTED OR REFLECTED METHOD.

In this examination the patient is seated or stands; the source of illumination is on the side corresponding to the eye under examination, in the same plane as the eye and just far enough back for the face to be thrown into the shade. Seated or standing at a certain distance, usually from 12 to 18 inches, the observer places the ophthalmoscope to either eye and, looking through the aperture, casts the rays gathered from the source of illumination into the patient's eye. If the media be clear a more or less reddish reflex is ob-

served, corresponding to the size of the pupil. The light being kept upon the pupil, the patient is told to look in all possible directions.

The Vessel Test and Shadow Test, which we have made subdivisions of the Transmitted Method, we will treat in chapter VIII.

THE OBLIQUE ILLUMINATION.

The source of illumination is on the side corresponding to the eye under examination, in the same plane as the eye and slightly in front of it. The rays of light are concentrated upon the eye by means of one of the biconvex lenses (preferably the strongest), contained in the instrument case. The patient is made to look in all possible directions.

The vision of the observer may be materially aided by the use of a convex lens held between his eye and that of the patient, so that it may act as a magnifying glass. This lens may be held in the disengaged hand or one may use a pair of strong convex eye glasses. . By means of this method the conjunctivæ the cornea, aqueous humour, the lens with its capsules, and the anterior portions of the vitreous humour may be carefully inspected. Artificial illumination is preferable, though at times *reflected* sunlight may suffice. The direct rays of the sun should, of course, never be concentrated on the eye.

By means of the first two general methods we convince ourselves of the condition of the media

namely, commencing from before backwards, the cornea, the aqueous humour, the lens with its capsules (anterior and posterior),and the vitreous body—at least to the extent of the area of the pupil. Now if there be in any of the media within this area, an opacity, it will stand out in the field of the pupil as a dark spot on the reddish background when the reflected method is employed. Let us suppose that on throwing in the light by this method, we discover the presence of an opacity. We proceed to locate it.

We exclude the cornea and aqueous humour first by means of the oblique illumination, we can also, by this means, as stated, explore the lens and the anterior portions of the vitreous body, but for this purpose it is generally necessary to have the pupil dilated. Suppose we have excluded the cornea and aqueous humour and have located the opacity in the lens. We must decide whether it be on the anterior capsule, the posterior capsule, or, if in the lens substance, in what portion.

In order to settle this point let us regard the eyeball as a sphere, with an anterior pole, a posterior pole and an equator. Within this sphere is placed the lens which may also be considered as a sphere, with two poles (anterior and posterior), and an equator. The lens is fixed in the ball anterior to its equator. Whenever the ball moves the lens moves with it and any point situated on the anterior surface of the lens will move with a corresponding point situated

on the anterior surface of the ball; any point on the posterior surface of the lens will move with any corresponding point on the posterior surface of the ball.

Having hypothetically located the opacity in the lens, suppose we find by the reflected method that it moves upward when the eye is rolled upward, downward, when the eye is rolled downward (*i. e.* moves *with* the eye), we conclude that the opacity lies anterior to the lenticular equator.

Suppose the opacity moves downward when the eye is rolled upward, and upward when the eye is rolled downward (*i. e.*, *against* the movements of the ball), we conclude that it must be posterior to the lenticular equator.

Having in this manner decided that the opacity is anterior or posterior to the lenticular equator, we next proceed to locate it either in the capsule or in the cortical substance. The opacities which occur on the capsules have, as a rule, appearances quite characteristic, and a knowledge of these together with the alternate employment of the oblique and reflected methods enables us quite definitely to decide their location.

The opacities occurring on the capsules are usually anterior and posterior polar cataracts. Anterior polar cataract appears generally as a *white* spot (by the oblique method), or a *dark* spot (by the reflected method); or, it may, by the oblique illumination, appear as a whitish pyramid projecting somewhat into

the anterior chamber; by the reflected light this latter form would appear as a more or less dark square. Of course there may be other opacities on the anterior capsule. Posterior polar cataract is generally star-shaped.

Suppose the hypothetical opacity moves *with* the eye; and suppose we have excluded the cornea, aqueous humor and anterior capsule by the oblique illumination, the opacity must then be in the anterior cortical substance by exclusion. A star-shaped opacity in the lens that is seen to move *against* the movements of the ball may be diagnosed as posterior polar cataract.

If there be an opacity in the optical centre of the lens, the so-called axial cataract, there is practically no movement of the opacity when the eye is rolled in the various directions. The points of opacification in progressive lenticular cataract may be found in any or all parts of the lens-substance.

To sum up: If an opacity moves regularly with the ball, it is either in the cornea or lens, the oblique illumination will exclude the cornea; it may be located in the lens in the way shown above.

If an opacity moves in a direction opposite to that of the ball, it cannot be in the cornea and is probably in the lens, posterior to its equator.*

Another medium remains for our consideration, the

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*A fixed opacity of any description in the vitreous body would constitute an exception to the last clause.

vitreous humour. If we have discovered an opacity in the media, and the cornea, aqueous humor and lens have been excluded, as its locality, we decide that it must be in the vitreous humour. Opacities in the later usually float; they sweep about in the field of the pupil irregularly, when the ball is moved about. They may have many shapes, *may* also be fixed, diffuse or circumscribed and may differ in degree of opaqueness.

It must be borne in mind that cholesterine particles occur in the vitreous humour. They do not appear dark, but on the contrary, as bright, highly refracting particles that dance about at will when the eye is moved. Opacities in the vitreous humour are usually detected by the transmitted method; though when far forward, they may be recognized by the oblique illumination.

CHAPTER VI.

THE INDIRECT METHOD.

This method enables us to recognize the quality of the refraction present in an eye, to measure the quantity approximately and to examine the condition of the fundus. The rays of light are reflected into the patient's eye; as they emerge from it they are caught on a biconvex lens, held immediately in front and are focussed in the air between the observer and the patient.

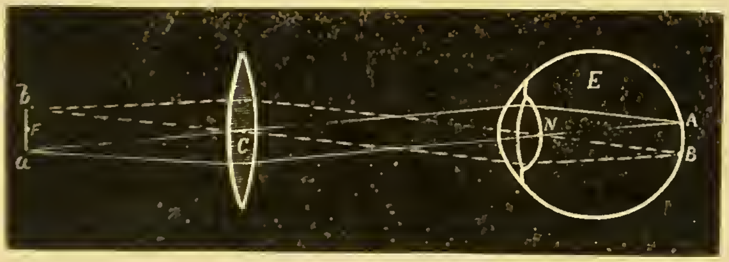

FIG. 23.

The rays coming from A, pass through the biconvex lens, C, and are focussed at a. The rays coming from B are focussed at b. The rays coming from A and B form then inverted images of A and B in the air.

The image of the fundus is therefore inverted and the landmarks are found in positions opposite to those they are found to occupy in the anatomical examination.

The light should be placed on the side corresponding to the eye examined, in the same plane as the eye and just far enough behind the patient's head to throw the face into the dark.

The patient should be directed to look *over* the shoulder of the observer, which is *diagonal* to the eye under examination, *i. e.*, over his right shoulder for the right eye, over his left shoulder for the left eye. This insures relaxation of the accommodation and a certain degree of dilatation of the pupil; in addition, it brings the optic disc more nearly into a direct line with the pupil, since, in the anatomical position of the parts, the optic disc is slightly to the inner side of the median line. Stress should be laid on making the patient look *over* the shoulder, and not *at it* or the *ear*. We prefer to stand while the patient sits, but for beginners it is perhaps best for both observer and patient to be seated. At a distance of 18 to 20 inches (arm's length), the observer, looking through the aperture of the ophthalmoscope, throws the light into the eye; having a good reflex, with the biconvex lens held between his thumb and index finger, and his little or ring finger supported on the forehead of the patient, he brings down the lens into the track of the rays as they emerge from the patient's eye. The lens should not be brought down until the reflex is observed. When it is lost, the objective should be lifted until it is found again.

The strict observance of this rule will save a

world of trouble. Classically, when examining the right eye of a patient, the observer should use his left eye and hand for the instrument, and should hold the objective in his disengaged right. For examining the left eye, the opposite should be done. The majority of surgeons do not observe this rule, but use the right eye and hand always for the ophthalmoscope. If the upper lid of the patient should droop, as in ptosis, or when he is wearied, it may be lifted by the ring finger, while the little finger is propped against the forehead.

Theoretically, the objective should be held at right angles to the optic axis of the eye. If this is done, however, the reflexes on the anterior and posterior substance of the lens, coming together, will disturb the vision. The lens may be slightly tilted in order to place an undisturbed space between the two reflexes. (Loring).

After some experience one becomes able to ignore these reflexes. The beginner usually sees best in this examination, if he be emmetropic, through the aperture; when, however, he has acquired the power and habit of relaxing his accommodation, he will find that if a convex glass be turned on behind the aperture, it will improve the vision by magnifying the ærial image. This method of examination is certainly more difficult to learn than the Direct. It is nevertheless indispensable in the proper examination of the eye. It does away with the unpleasantness often experienced in the examination of dispensary patients by

the direct method. It can be done rapidly, and in many cases, as in high degrees of ametropia (particularly myopia), where the fundus can be seen only indistinctly by the direct method, supplants the latter.

In regard to the strength of the objective to be used we would say that either one of those contained in the case may be employed; for beginners, the weaker is better, since the image appears larger when seen through this.

The disc is the point to be looked for. The macula lutea cannot be seen as a rule.

In *emmetropia* the disc appears round and of a certain size. As the objective is moved towards and away from the eye, the size and shape of the disc remains constant. The optic disc may not be round even in E, for, it may be misshaped anatomically. Under such circumstances, however, it would retain the same shape when the objective is withdrawn.

Since rays emerge from emmetropic eyes parallel, the image formed will always be at the same distance from the lens and since the "relative sizes of image and objective are as their distances from the lens" (Morton), the size of the image will remain constant when the objective is withdrawn.

Fig. 24 represents an emmetropic eye from which the rays of light emerge parallel; the focus is formed at the same distance from the lens, at whatever distance the latter is held from the eye.

In *simple hypermetropia*, the disc appears larger

than in E, but diminishes in size in all meridians equally as the objective is withdrawn. Rapid and marked diminution indicate a high degree of H, slight diminution, a low degree.

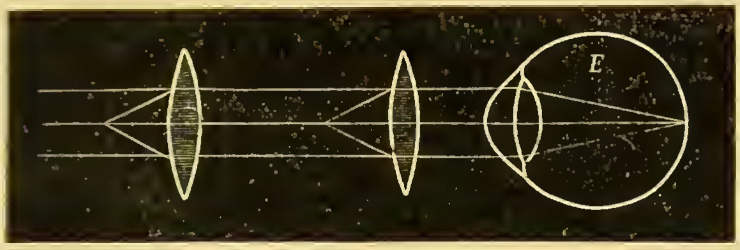

FIG. 24.

As the rays emerge from the hypermetropic eye, they have the characteristic of rays that come from objects *nearer* than infinity, namely, *divergence;* since the size of the image in convex lenses is smaller the further the object is removed from the lens (within 20 feet), the image of the disc in the indirect method appears smaller in E. than it does in H.; conversely it appears larger in H. than in E.

In *simple hypermetropic astigmatism* the disc diminishes in one meridian as the objective is removed, but remains constant in the other. The astigmatism is in the meridian that decreases. The axis of the correcting glass would lie at right angles to this.

In *compound hypermetropic astigmatism* the disc diminishes in all meridians but more in one than in the opposite; that meridian is more hypermetropic, *i. e.*, astigmatic, in which there is the greater decrease.

In *simple myopia* the disc appears smaller than in E., but increases in all meridians equally as the objective is withdrawn.

Rapid and marked increase indicates a high degree of M, slight increase, a low degree.

Since rays issue from myopic eyes convergently, in passing through a convex lens they will be focussed more rapidly, that is nearer to the lens, than parallel rays would be. The image of the disc is therefore smaller in M than in E.

In *simple myopic astigmatism* the disc increases in one meridian as the objective is withdrawn, while it remains constant in the opposite. The astigmatism is in the meridian that increases. The axis of the correcting glass would be at right angles to this.

In *compound myopic astigmatism* the disc increases in all meridians, but more in one than in the opposite; that meridian is more myopic, *i. e.* astigmatic, in which there is the greater increase.

In *mixed astigmatism* one meridian decreases while the other increases. There is present As. H.M. or As.M.H., accordingly as the H. or the M. predominates. In correction, the convex cylinder would have its axis at right angles to the meridian in which there was decrease on withdrawing the lens; the concave cylinder would have its axis at right angles to the meridian in which there was increase; in other words, the axis of the convex cylinder would lie parallel with the myopic meridian, that of the concave cylinder, parallel with the hypermetropic meridian.

The simple presence of astigmatism may be recognized by oblongness of the disc when the objective is held before the eye without being moved. It has been stated what the change in the shape of the disc signifies when the objective is withdrawn.

We have already demonstrated that the disc remains constant in E when the objective is withdrawn.

An explanation of the cause of increase in M and of decrease in H when the objective is withdrawn, will not be amiss.

FIG. 25.

Fig. 25 represents a hypermetropic eye. The rays proceeding from A and B pass out of the eye divergently; they are focussed by the lens C, held in front of the eye at α β.

Fig. 26 represents the same eye with the same lens held at a greater distance from the far point, a-b, situated behind the eye; the focus is here formed at α β which is nearer to the lens than in the preceding figure. The formula previously given for finding the

distance of the image from convex lenses will serve us here.

FIG. 26.

Suppose our objective has a focal distance of two inches and it is held four inches in front of the far point of a hypermetropic eye, in the track of the diverging rays. What is the distance of the image from the lens?

$$\frac{1}{x} = \frac{1}{2} - \frac{1}{4} = \frac{1}{4} \therefore \times = 4 \text{ inches.}$$

Suppose the objective be removed to the distance of 8 inches from the far point. To find $\times$:

$$\frac{1}{x} = \frac{1}{2} - \frac{1}{8} = \frac{3}{8} \therefore \times = \frac{8}{3}\ 2\tfrac{2}{3} \text{ inches.}$$

"The ratio of the distance of the image from the lens as compared with that of the object from the lens" is *less* in the second case ($2\frac{2}{3}$: 8) than in the first (4:4). In hypermetropia, then, the disc diminishes as the objective is withdrawn.

Fig. 27 represents a myopic eye from which the rays A and B emerge convergently, forming an inverted

aerial image at $\alpha\,\beta$ the far point. This latter we must now regard as the object. It is of this object that we obtain a final image b a, by means of the bi-convex lens C.

FIG. 27.

Since the image and object are on the same side of the lens, the formula for finding the distance of the image from concave lenses, will serve us here:

$$\frac{1}{x} = \frac{1}{b} + \frac{1}{a}$$

Suppose our objective is a 2 inch lens and we hold it 8 inches from the far point, in the track of the convergent rays; what is the distance of the image from the lens?

$$\frac{1}{x} = \frac{1}{2} + \frac{1}{8} = \frac{5}{8} \therefore X = 1\tfrac{3}{5} \text{ inches.}$$

Suppose now we carry the objective further from the eye and hold it 4 inches from the far point. To find X

$$\frac{1}{x} = \frac{1}{2} + \frac{1}{4} = \frac{3}{4} \therefore X = 1\tfrac{1}{3} \text{ inches.}$$

"The ratio or the distance of the image from the

lens as compared with that of the object from the lens" is *greater* in the second case ($1\frac{1}{3}$: 4) than in the first ($1\frac{3}{8}$: 8)

In myopia, then, the image increases as the objective is withdrawn from the eye.

CHAPTER VII.

THE DIRECT METHOD.

By this method we are enabled to determine the quality and quantity of the refraction present in an eye and to examine the condition of the fundus. The patient and surgeon may be seated or standing according to circumstances or preference. The light should be on the side corresponding to the eye under examination, in the same plane as the eye and just far enough back to throw the face into the shade. It is often advantageous, especially in the case of children, to steady the head with the disengaged hand.

The surgeon should be slightly to that side of the patient which corresponds to the eye under examination. The patient should look straight out into distance or slightly towards the opposite side, in order to relax the accomodation, dilate the pupil and bring the disc into a line with the later. The surgeon places the ophthalmoscope to his eye—corresponding to the eye under examination, and, looking through the aperture, throws the light into the patient's eye. It is best to commence this examination at a distance of 10 or 12 inches. Having the red reflex distinctly, the observer approaches as near as possible, still keeping the light in the pupil and preserving the red reflex. The moment this is lost, it should be regained, before attempting to proceed further. The usual distance at

which the fundus is viewed in this examination is one or two inches. In order to render the chances of accommodating on the part of the surgeon and patient, least, it is well for both to become as comfortable as possible in their positions before commencing the examination. We have often observed, particularly in our own case, that one frequently falls short of the exact diagnosis, when in an uncomfortable position.

For the examination of the right eye, then, the observer should close his right eye, hold the instrument in his right hand and sit or stand slightly to the right of the patient. In examining the left eye, the opposite should be done. The index-finger should always be placed upon the ratchet or wheel so that the glasses may be turned on without taking the instrument from the eye. For our part, we prefer to stand, but, at times, it is far better to sit, as in the case of children or when it is desired to make a drawing of the fundus.

This method of examination may be used with great advantage for the minuter examinations of the vitreous body, lens or even cornea, by turning on strong convex lenses over the aperture.

In order to obtain an absolutely correct knowledge of condition of the refraction, neither the patient nor the observer should accommodate, and in addition, the latter should be emmetropic or *rendered so*, if ametropic.

As a practical matter we cannot eliminate accom-

modation entirely either on the part of the surgeon or patient. If there be no doubt that the patient is accommodating strenuously, this element of error should be eliminated by a mydriatic. Continuous practice is the only means by which the muscle of accommodation can be gotten under the control of the will.

If the observer, being emmetropic or rendered so, looks through the aperture of the instrument and sees the fundus distinctly, the patient is either hypermetropic or emmetropic, the weakest convex (+) glass should now be turned on; if the fundus does not appear as distinct as without the glass, the patient is emmetropic; if the fundus appears equally as distinct as through the aperture, the patient is hypermetropic and the strongest convex glass through which the fundus is seen distinctly, *minus* the distance between the patient's and the observer's eye is the measure of the hypermetropia manifest by the ophthalmoscope. From the above it may be concluded that if the fundus is seen *distinctly* by an emmetropic observer looking through the aperture, *myopia* is out of the question.

If an emmetropic observer *cannot* see the fundus distinctly, there is probably myopia.

There may be hypermetropia, in which case the observer either cannot overcome the divergence of the rays of light as they emerge from the patient's eye or *will* not overcome it; in other words, intentionally *relaxes* his accommodation.

(It is possible also for the observer or the patient, separately or together, to so accommodate, that the fundus is rendered indistinct. This last possibility, we will lay aside for the sake of clearness.)

If the weakest convex glass render the vision *more indistinct*, while the weakest concave glass renders it *more* distinct, there is myopia, and the *weakest* concave through which the details of the fundus are seen distinctly *plus*, the distance between the surgeon's and the patient's eye is the measure of the myopia present.

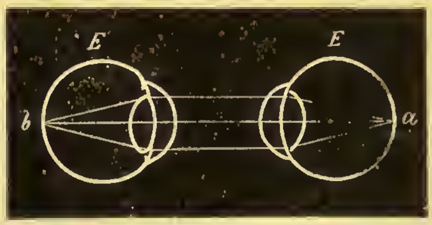

FIG. 28.

Fig. 28 represents two emmetropic eyes in a state of rest; the rays from *a* emerge from the eye parallel, and passing into the opposite eye, are focussed at *b*. A clear image of *a* is then formed on the retina of the observing eye at *b*. A convex glass interposed in the track of the parallel rays would obviously bring the rays to a focus before they reached the retina of the observing eye.

Fig. 29 represents two eyes, an emmetropic E and a hypermetropic H. Rays coming from *a* in the

hypermetropic eye H, emerge divergently, as if they came from R, the far point. The convex lens L renders them parallel, so that they are brought to a focus at *b*, situated on the retina of the emmetropic eye E. If the lens were *not* interposed, and the emmetropic

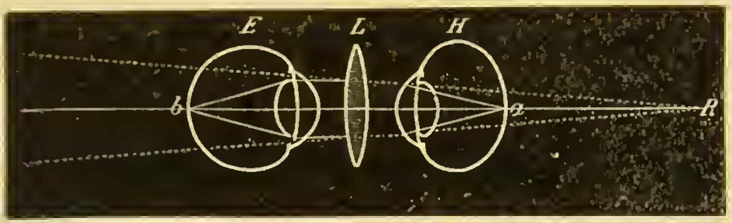

FIG. 29.

eye E remained in a state of rest, the focus would be formed behind the retina of the latter eye. The convex lens must be *just* strong enough to render the divergent rays parallel. If it be too weak to do this, the entering rays will still be divergent, and the observing eye would either see indistinctly or would have to use the muscle of accommodation to obtain distinct vision. The *strongest* convex glass, then, with which the fundus is seen distinctly is the measure of the H in a given case.

Fig. 30 represents two eyes, an emmetropic E and a myopic M. Rays coming from *a* in the myopic eye M emerging convergently, would come to a focus at R, the far point, if the eye *E* were not interposed The concave lens L gives the convergent rays exact

parallelism, so that they are focussed at *b* on the retina of the emmetropic eye.

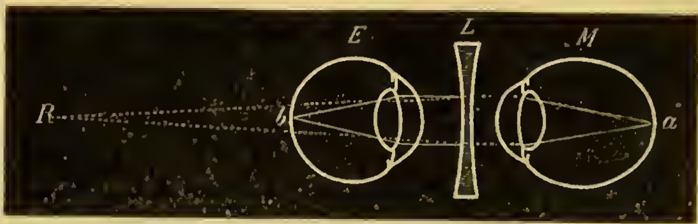

FIG. 30.

If the lens L be too weak to give the convergent rays parallelism, the observing eye will still see the fundus of the myopic eye indistinctly, for the entering rays, being still convergent, will be focussed in front of the retina. If the lens L be so strong as to give the convergent rays divergence, the fundus of the observed eye will be seen indistinctly, if the accommodation of the observing eye be relaxed, for then the focus would be formed behind the latter's retina; it may be seen distinctly, however, if the observer use the requisite amount of accommodation. The *weakest* concave glass, then, with which the fundus is seen distinctly is the measure of the *M* in a given case.

We have spoken thus far of simple or spherical error; we come on now to the consideration of astigmatism.

In the following the surgeon is assumed to be emmetropic (See "Perception of a Line," p. 23.)

SIMPLE HYPERMETROPIC ASTIGMATISM.

If the vessels of the vertical meridian, let us say, are seen distinctly through the weakest convex glass, while the horizontal vessels are rendered indistinct, by it, there is AS. H. in the horizontal meridian. The axis of the correcting glass would lie vertically.

COMPOUND HYPERMETROPIC ASTIGMATISM.

If the vessels of the vertical meridian can be seen distinctly through a convex glass of a certain strength, while those of the opposite meridian, the horizontal, can be seen through a *stronger* convex glass, there is AS. H., + H.

The excess of error is at right angles to the horizontal meridian, *i.e.*, in the vertical meridian. The axis of the correcting cylinder would lie horizontally.

SIMPLE MYOPIC ASTIGMATISM.

If the vertical vessel can be seen distinctly through the aperture, while the horizontal vessel can be seen distinctly *only* through a concave glass, there is myopia in the vertical meridian. In order to exclude hypertrophia in the horizontal meridian, it would be necessary to turn on the weakest convex glass; if this renders the vertical vessels less distinct, there is emmetropia in the horizontal meridian. The case would then be one of AS. M. in the vertical meridian.

The axis of the correcting cylinder would lie horizontally.

COMPOUND MYOPIC ASTIGMATISM.

If the horizontal vessels can be seen distinctly *only* through a concave glass of a certain strength, while the vertical vessels can be seen distinctly *only* through a *stronger* concave glass, there is AS. M. + M., The excess of error lies in the horizontal meridian. The axis of the correcting cylinder would lie vertically.

MIXED ASTIGMATISM.

If the vessel of the vertical meridian can be seen distinctly *only* through a concave glass, while those of the horizontal can be seen distinctly through a convex glass, there is AS.M.H., or AS.H.M., accordingly as the M. or the H. predominates.

The axis of the concave cylinder would lie vertically; that of the convex cylinder, horizontally.

The measurment of the degree of astigmatism is subject to the same rules as the measurment of spherical errors.

It will be observed, by reading the foregoing, that *the axis of the correcting cylinder should always be laid parallel with that meridian, which is found to be astigmatic by the Direct Method.*

At times it is necessary to measure the refraction of the eye at various points on the fundus, as for example, in the measurement of the depth of an excavation of the disc or of the extent to which a tumour projects into the vitreous humour. In the case of an

excavation of the disc the measurement of the edge should first be taken, then that of the bottom. In the case of a tumour, the refraction at its apex or forward limit should be estimated; then the refraction at its base. The difference between the two measurements would give us, in the first case, the depth of the excavation, in the second, the extent of the projection of the tumour.

In E. the details of the fundus are bright, distinct and magnified.

In H. one is struck by the fact that the details of the fundus stand out with remarkable brilliancy and distinctness (if accommodation be used sufficiently); the disc and vessels are sharply and clearly cut and appear *smaller* than in the emmetropic eye; they seem to be removed to a distance backward; in fact, one gets the impression of looking through a concave glass. The area of the field seen is smaller than in E. These features are often enough for an expert to base the diagnosis upon, or at least are enough to warrant a reasonable suspicion of the refractive condition present.

In M. the fundus appears indistinct, nor can any effort of accommodation on the part of the emmetropic observer render it less indistinct. When the disc and vessels can be made out, they appear much larger that in E. The area of the field seen is greater than in H. The field of vision in all cases, however, depends primarily upon the size of the pupil of the person under examination.

We have spoken in the foregoing of the distance between the eye of the surgeon and that of the patient. We should more strictly speak of the distance between the "nodal points" of the two eyes. In M. we have stated that this distance is *added* to, in H. *subtracted from* the measure found at the distance of the observer.

If the eye under observation be hypermetropic the rays will emerge from it divergently, vid. Fig. 20. An emmetropic eye in a state of rest cannot focus such rays on its retina. Hence by means of a convex lens the divergent rays must be rendered parallel.

Suppose the H. in a given case equals $\frac{1}{8}$. The far point of such an eye lies 8 inches behind its nodal point. If the glass could be placed at the nodal point of the observed eye a $+\frac{1}{8}$ would render the divergent rays parallel. If the measurement be made two inches in front of the nodal point, the distance from the far point would be ($8 + 2 = 10$) 10 inches, and it would require a plus $\frac{1}{10}$ to render the divergent rays parallel; $10 - 2 = 8 = \frac{1}{8}$ strength.* Hence the refraction of a hypermetropic equals the strongest convex glass through which the fundus is seen distinctly *minus* the distance of the correcting glass from the nodal point of the observed eye.

If the eye under observation be myopic, rays will

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* The addition and subtraction must be made in integers, since the fraction is only the expression of the strength.

emerge from it convergently, vide Fig. 21. An emmetropic eye receiving these rays will not be able to focus them upon its retina, since such an eye in a state of rest is focussed for parallel rays only. Hence by means of a concave lens the convergent rays must be rendered parallel. Suppose the observed eye is myopic to the extent of $\frac{1}{6}$. The far point of such an eye lies at the distance of 6 inches in front of the nodal point. If the surgeon could place the correcting glass at the nodal point of the observed eye, a minus $\frac{1}{6}$ would render the convergent rays parallell. But this is practically impossible. Two inches is the usual distance at which the measurement is taken. This would place the surgeon two inches nearer the far point of the observed eye, *i. e.* 4 inches from it, $(6—2=4)$ and a $\frac{1}{4}$ would be required to render the rays at this point parallel; $4+2=6=\frac{1}{6}$ strength. Hence the refraction of a myopic eye equals the weakest concave glass through the fundus is seen distinctly *plus* the distance of the correcting glass from the nodal point of the observed eye.

CHAPTER VIII.

THE VESSEL TEST—THE SHADOW TEST.

The Vessel Test, it will be remembered, together with the Shadow Test, Retinoscopy, we have included under the head of the Reflected Method.

By means of the Vessel Test we are able to tell the quality of the refraction in a given case; approximately, also, the quantity. The light should be so placed that the face of the patient is thrown into the dark.

The surgeon should sit or stand at a distance usually, of 16 or 18 inches. Looking through the aperture of the instrument he throw's the light into the patient's eye.

If emmetropia be present, while the reflex is bright, the vessels of the fundus will not be seen. A glance at fig. 31 will explain this. The rays from the two points, m and n situated on the retina, emerge from the eye parallel, but since the two bundles of rays cross each other on their way out, they finally diverge so widely, that an eye placed at A receives none of them.

Now it must be borne in mind that such bundles of rays proceed from all points on the fundus, so that though many rays are received, not enough are caught to make a distinct image. In H, the vessel can be

seen. If the surgeon move his head, holding the mirror stationary before his eye, and the vessels be found to move *with* his head, *H*, is present.

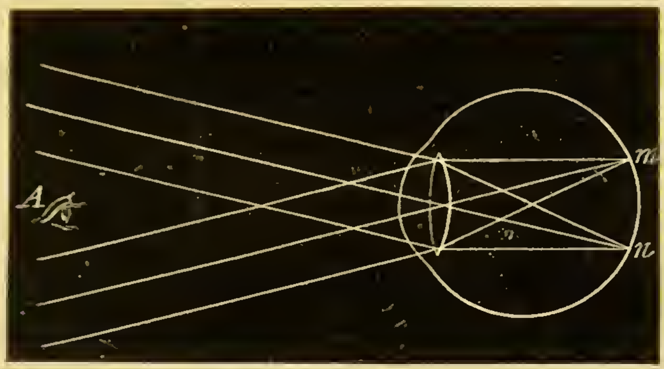

FIG. 31.

In M. also the vessels can be seen.

If the surgeon move his head and the vessels be seen to move in a direction *opposite* to that of his head, *M*. is present.

If the case be one of a very high degree of ametropia, the vessels are not seen at the usual distance and the reflex appears indistinct and dim. This enables us to make an approximate estimation of the degree of A present in a given case.

If it be a case of a high degree of H, the rays diverge so rapidly on emerging from the eye, that at the usual distance, only a few are caught by the observer's eye.

If it be a case of a high degree of M., the rays

converge so rapidly on emerging that a focus is found very near the patient's eye; from this point the rays diverge with such rapidity that practically the same thing takes place as in a high degree of H.

Let it be remembered that the image seen in myopia is an ærial and inverted one (when the surgeon is beyond the far point); that in hypermetropia it is upright and apparently behind the eye.

If the surgeon get within the far point of a myopic eye, the vessels will not be seen distinctly, if the observer be emmetropic, unless he use a concave glass.

Very slight degrees of A can not be detected by this means of examination with the usual ophthalmoscopic mirror.

It is taught by some that simple, compound and mixed astigmatism may be diagnosed by the vessel test. We deem this practicable only for the most consummate experts.

Irregular lenticular astigmatism may be recognized by the vessel test.

"Instead of the vessels moving regularly and evenly, they move slowly across the centre of the pupil, but rapidly and irregularly toward the periphery, giving the appearance of rotating bent spokes of a wheel."

In irregular corneal astigmatism, the characteristic facets appear darker than the surrounding normal cornea, owing to the fact that their refraction is dif-

ferent from that of the latter. This last form of irregular astigmatism may also be easily recognized by the oblique illumination.

THE SHADOW TEST OR RETINOSCOPY.

This method has been erroneously termed kerato-scopy.

As a qualitative and quantitative method of determining the condition of the refraction of the eye, it is of undoubted value.

Its adoption has been slow upon the European continent and especially in this country, while in England it is popular and universal.

The following well-known and simple experiment will enable us to understand the behavior of the determining elements in retinoscopy, viz.: light and shadow.

If rays of light be reflected from a concave mirror upon a screen placed beyond its focus, they will arrive at the screen in divergence.

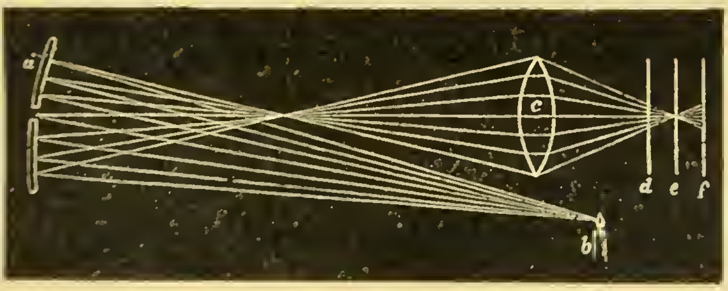

FIG. 32.

A convex lens may now be interposed in the track of these divergent rays and a perfectly distinct image of the source of the illumination may be formed on the screen, e, fig. 32.

The image will be upright, since the rays have been focussed twice, once in the air at the focal point of the concave mirror, as an inverted image, a second time on the screen, as the reverse of the inverted, namely, an upright image. When the lens is held so as to make the image perfectly distinct, the illumination will be brightest and there will be around the image a sharply defined dense shadow whose edge will more nearly approach a straight line. If now the lense be moved either towards or from the screen or the screen towards or from the lens, the image will not be distinct, the illumination will appear less bright, the shadow less dense and its edge more curvilinear, since "circles of diffusion" will be formed upon the screen, d. f. (fig. 32).

If now the mirror be turned on its vertical axis, to the right or the left, or upon its horizontal axis, from above downward or the reverse, it will be seen that the light and shadow move *against* the mirror. The movement of the light and shadow will be the same in whatever direction the mirror be tilted. The media of the eye are represented in the above by the lens, the retina by the screen. In fig. 32, *e* represents the retina of an emmetropic, *d* that of a hypermetropic, *f*, that of a myopic eye.

We speak of the movement of the shadow; we should speak more properly simply of that of the light, since the shadow is an absence of the light.

As custom and want have sanctioned "shadow," we will use it in the following.

The light is placed *over* the patient's head and far enough back to throw the face into the shade. The patient is directed to look *over* that shoulder of the surgeon which is diagonal to the eye under examination. If the patient be under the influence of tropine, we may get the refraction at the macula lutea, by making the patient look into our face. When atropine has not been employed, we can not hope to get the refraction at the macula, and must content ourselves with taking it at the disc. The reasons for making the patient look *over* the shoulder have been sufficiently explained.

The surgeon sits or stands at a distance of about 48 inches, and uses a concave mirror, generally, of nine inches focal distance.

If the A be of a very high degree, the surgeon must be nearer than the regular distance, 48 inches, in order to see the movement of the shadow distinctly.

The light is thrown into the patient's eye, and the the mirror is rotated in all directions, vertically, horizontally, obliquely.

As the ophthalmoscope is tilted, a shadow is observed to creep from under the iris at the periphery of the pupillary field, and to pursue a definite course in the latter.

The movement of this shadow, as compared with the movement of the mirror, furnishes the means of determining the refraction.

If the shadow move *against* the mirror, there may be hypermetropia, emmetropia, or a low degree of myopia.

If the shadow move *with* the mirror, there is myopia.

We have seen in the experiment with our screen and candle that the direction of the shadow is always *against* the movement of the mirror, whether the screen be held at e, d, or f (Fig. 32). Now as *e* is situated at the principal focus of the lens, rays coming from this point will pass through the lens and emerge parallel; as *d* is situated within the principal focus, rays coming from this point will emerge from the lens divergently; as *f* is situated beyond the principal focus, rays coming from this point will emerge from the lens convergently, but their convergence will be so slight that they will unite *behind* the eye of the observer who is presumably at the distance of 48 inches. These rays are practically the same as divergent or parallel rays since the observer is within their focus. The movement of the shadow is the same then in H, E, and M, which is less than $\frac{1}{48}$. If now the myopia be so great that the focus (far point) lies between the surgeon and the patient, the movement of the shadow will be reversed, *i. e.* it will move *with* the mirror.

In myopia three images are formed when retinos-

copy is used; first the inverted image of the light formed at the focus of the concave mirror, then the upright image in the eye, and finally the inverted image again, in the air.

We have spoken thus far of H. and M. in general terms. It is necessary, however to "differentiate" simple or spherical errors from meridional errors, and in case of astigmatism to "differentiate" the various kinds.

We have already shown that in E. the illumination is brightest, the shadow is densest, and that the latter's edge most nearly approaches a straight line; that in ametropia, the illumination is dim, the shadow less dense and the latter's edge is curvilinear in direct proportion to the degree of ametropia.

There is still another determining element, the rapidity with which the shadows move.

In emmetropia, the far point lies at infinity; in myopia, at a finite distance in front of the eye; in hypermetropia, at a finite distance behind the eye.

The higher the degree of H or M, the nearer is the far point to the nodal point.

Fig. 33 represents a myopic eye. Let a line be drawn from A, a luminous point on the retina, through the nodal point B to C.

Since the eye is myopic, an inverted image of A. is formed somewhere on this line, let us say at C. The higher the degree of M., the nearer will the image (far point) be to the nodal point. Let us assume,

then, that there is another far point at D. When the mirror is tilted from M to M′, C and D move through arcs of circles; D moves to d and C to c, each moves through its respective arc in the same time; since C's

FIG. 33.

arc is greater than D's, C must move the faster—conversely, D moves more slowly than C.

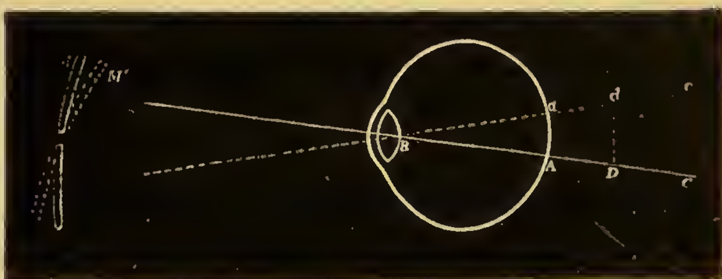

FIG. 34.

Fig 34 represents a hypermetropic eye. The image is situated behind it. We assume, as above, the presence of two far points, one at C, the other at D.

When the mirror M is moved to M′, C moves to c and D to d; each moves through its respective arc in the same time; since C's arc is greater than D's, C must move the faster. In each case D has been nearer to the nodal point than C. The slower the movement of the shadow, then, the greater the degree of the ametropia. Since the far point of an emmetropic eye lies at infinity, the shadow moves with the greatest degree of rapidity in E.

The characteristic appearance in this latter condition has been described by one writer as "irregular play of light and shadow."

In teaching we describe the movement of the shadow in E. as a *flitting* movement.

If the shadow move with equal rapidity in all meridians, there is simple myopia, hypermetropia, or, emmetropia.

The significance of the direction of the shadow has been given. The "differentiation" between H., E. or a low degree of M. will be given presently. In astigmatism the same general rules obtain. If, for instance, the shadow move with the mirror in the vertical meridian, there is M in this meridian; if it move in the opposite direction in the horizontal meridian, there may be in this H., E., or a low degree of M. If the shadow move *with* the mirror in each meridian, but more slowly in one, with greater curvature of its edge, and with less illumination than in the other, there is compound myopic astigmatism and the astigmatism is

in that meridian *along which* the shadow moves more slowly, with less illumination and with greater curvature of its edge.

If the shadow move *against* the mirror in each meridian, but with greater curvature of its edge, less illumination and more slowly in one than in the other there is probably compound hypermetropic astigmatism.

There is certainly H. in the meridian along which the shadow moves *more slowly* but there may in the other H., E., or a low degree of M., as we have shown.

If the shadow move against the mirror in one meridian and with it in the opposite, we certainly have M. in one and perhaps H. in the other *i. e.* mixed astigmatism. But we must exclude E. and a low degree of M. from that meridian along which the shadows move against the mirror, before we can make an absolutely certain diagnosis. A little experience will enable anyone to recognize the characteristic *flit* of emmetropia. As a practical matter, then, when we see a shadow that has not this *flit* but rather a *well defined* movement against the mirror, we may conclude in favor of H.

If the astigmatism be vertical or horizontal, the shadow of the vertical meridian will be seen when the mirror is rotated on its horizontal axis, the the shadow of the horizontal meridian will be seen when the mirror is rotatated on its vertical axis.

If the astigmatism be oblique, the shadow will

always be oblique, it matters not in what direction the mirror is tilted. A glance at Fig. 35 will explain this:

FIG. 35.

Let us place obliquely behind the circle, which represents the pupil, an oval piece of card, to represent the light or shadow on the retina. If we move the card across the circle in the direction OD, it will have the appearance of moving in the direction OC, which is at right angles to its edge. The oblique edge of the shadow is due to the shape of the image on the retina and not to the direction of the movements of the mirror.

We come now to the differentiation between H, E, and low degrees of M when the shadow moves *against* the mirror. For this purpose *the patient* should put on a spectacle frame. If +.5 D ($\frac{1}{80}$) placed in the spectacle frame before the patient's eye, reverse the shadow, *i. e.*, make it move *with* the mirror, there is a low degree of M present. To illustrate, suppose the patient is $\frac{1}{80}$ myopic, if the observer stand at the dis-

tance of 48 inches, the far point of the patient's eye is 32 inches behind his head ($80 - 48 = 32$). If $+ \frac{1}{80}$ be added to the degree of the patient's myopia, the far point is brought to 40 inches from the latter's eye. The observer standing at the distance of 48 inches, sees the movement of M.

But suppose that $+ \frac{1}{80}$ does not reverse the shadow, that it still moves against the mirror; under these conditions we assume that there is no myopia, or if present, that it is so insignificant as to require no correction.

We next proceed to the exclusion of either H or E. If + 1D ($\frac{1}{40}$) placed before the patient's eye reverse the shadow, emmetropia is present.

It is evident that .5D ($\frac{1}{80}$) will not reverse the shadow, if E be present, since this glass will render an emmetropic eye artificially myopic to the extent of only $\frac{1}{80}$; the far point under such a condition would be behind the observer's head. If $+ \frac{1}{40}$ be added to an emmetropic eye, its far point would lie at 40 inches, since the eye is rendered this much artificially myopic. Under such a condition the surgeon being at a distance of 48 inches would observe the movement of M.

It is evident then that, if neither .5D nor 1D reverse the shadow, H must be present.

In making an approximately quantitative determination of the refraction of a given case we may sum up:

The less brilliant the illumination, the slower the

movement of the shadow and the more curvilinear ("crescentic") its edge, the higher the degree of A.

In astigmatism, that meridian is astigmatic along which the shadow moves.

For the exact quantitative determination of the refraction, the spectacle frame, placed on the patient, should again be used.

In *myopia* the *weakest concave glass which reverses* the movement of the shadow is practically the measure.

But we have shown that with .5 D of M, the shadow will move against the mirror; for the sake of greater accuracy then, —.5 D should be added to the first glass which reverses the shadow in m.

In hypermetropia, practically, the *strongest* convex glass with which the shadow *still shows the movement of H.*, gives the measure. If, however, we add glasses till the movement is reversed, we should subtract *1 D.* from the first glass that reverses the movement. The reason of this will be clear, if the preceding differentiation be borne in mind.

In correcting astigmatism the axis of the cylinder must be placed at *right angles to the meridian along which the shadow moves.*

In correcting AS.H. + H. or AS. M. + M, the meridian of less error should be first corrected by an appropriate spherical glass, the other meridian afterwards by the appropriate cylindrical glass.

In correcting mixed astigmatism, two cylinders

may be used with their axes at right angles to each other, or one meridian may be corrected with a spherical glass; this would obviously increase the error in the opposite meridian, which might then be corrected by the appropriate cylinder, as in the functional examination.

If a plane mirror be used, the movements of the shadow will be reversed, that is, it will move *with* the mirror in H., *against* it in M., while the other signs remain unaltered.

In the determination of the refraction of the eye with the ophthalmoscope, it must be remembered that accommodation on the part of the patient will cause incorrect results to be obtained. An emmetropic eye may appear myopic, a myopic, more myopic; a hypermetropic eye may accomodate so as to appear just emmetropic, or may appear to a high degree myopic. Thoroughly accurrate results cannot be obtained unless the accommodation be eliminated.

In the direct method, the accommodation of the surgeon also comes into play, and if he be young, it is quite improbable that he entirely relaxes it.

In retinoscopy, the stimulation to accommodation, both on the part of patient and surgeon, is least; the patient looks into the distance and fixes no object; the surgeon is at a considerable distance from the patient, and has to look only through the aperture of the instrument, no convex or concave glasses are placed before *his* eye, and accommodation on *his* part

will not mark the results. It seems to us that this much is enough to commend retinoscopy. Moreover, in a certain class of patients, young children, ignorant and foolish people, and idiots, from whom one can get no answer at all, or, at best, an uncertain one, in the functional examination, retinoscopy is, in our opinion, of peculiar advantage; indeed, preferable to the direct method.

We are not unaware that many American surgeons, of the highest repute, depreciate this method of examination. The late Dr. Loring, of New York, who, perhaps, wrote the best book in English on the refraction of the eye, states that the method has never proved of any value in his hands. The majority of the glasses prescribed at Moorfield's Hospital, London, are determined by retinoscopy. That the method is not difficult to learn has been attested by the rapidity with which students, working at our clinic, in the New York Polyclinic, have acquired it, learning it far more rapidly than either the direct or indirect method.

We do not hold that it or any other single method of examination should be employed to the exclusion of others, but we do hold that it is preferable in many cases and of advantage in all.

CHAPTER IX.

MYDRIATICS.

At times the pupils are so small that even in the dark room sufficient light is not admitted to get a clear or satisfactory view of the fundus. At times, also, it is necessary to eliminate the accommodation, as we have seen. For simply dilating the pupil without reference to paralyzing the accommodation, a 2-per-cent. or 4-per-cent solution of cocaine hydrochlorate is highly to be recommended. Formerly, gelatine discs of homatropine were much used, or a weak solution of the same agent. Although the effects of this drug last but 12 to 24 hours, it is not now to be considered for the simple purpose of dilating the pupil. In the dark room, cocaine hydrochlorate (4-per-cent. solution) will dilate some pupils almost *ad maximum*, while the effect upon the accommodation is so slight that it demands no consideration. The effect upon the pupil passes off in a few hours.

For the sake of paralyzing the accommodation and dilating the pupil, the sulphate of atropia has for a long while been the agent *par excellence*. Repeated instillations of a one (grs. v to ℥ i) or two (grs. x to ℥ i) per cent. solution will effectually attain this end. Weaker solutions we have found inadequate. With this drug the "point of toleration" is easily reached, especially in the case of children; this should be borne carefully in mind.

Among mydriatics duboisine should be mentioned. This drug paralyzes the accommodation and dilates the pupil *ad maximum.* It is more rapid in attack than atropine and its effects pass off more quickly. It was first used in ophthalmology a number of years ago particularly for the purpose of paralyzing the accommodation with reference to gaining an accurate knowledge of the refraction. It was soon laid aside, however, for the sulphate of atropia, which is now almost universally used for the above purpose. We have used a mixture of duboisine and cocaine for the same purpose with excellent results, in the following proportions:

Duboisini, grs. iiss.
Cocaini hydrochlor., grs. xxx.
Acidi borici, grs. xv.
Aquæ destill., ℥ j.

Duboisine was laid aside chiefly on account of certain cerebral symptoms which were observed under its use at the hands of several experimenters. Up to the present time, we have used the above solution for the purpose of dilating the pupil and paralyzing the accommodation not less that 150 times; no unpleasant symptom has been found to follow its use. The quantity employed has never been more than five drops in each eye. In test experiments made with this solution in emmetropic eyes, it has been found that the accommodation was entirely paralyzed in from one-half to one hour; the effects on both the pupil

and accommodation entirely disappear by the evening of the second day or the morning of the third after its instillation.

By the use of this formula the final examination can be made in three days.

The amount of time saved in this way is of great value to those engaged in the active pursuits of life. We have settled to our own satisfaction, by observing a large number of cases, that the eyeball tension is *diminished* by the instillation of this solution. This in itself is an advantage over atropine which, if instilled for a number of days, may cause increase of tension. Moreover it has never been necessary to make more than two examinations under the influence of this mixture.

The examination following the second day's instillation has always been satisfactory as attested by the accompanying ophthalmoscopic examinations. We deem this solution superior to duboisine alone, or to atropine sulphate alone, or to the latter in combination with cocaine. We have noticed that eyes treated with this solution more nearly accept the total correction of their errors than those treated with atropine. The hydrobromate of homatropine in 1 per cent. or 2 per cent. solution *is said* to completely paralyze the accommodation.

It is very expensive and not commonly found in the shops.

Daturine and hyoscyamine, although they par-

alyze the accommodation and dilate the pupil *ad maximum* are not in vogue for these purposes in ophthalmology.